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ECONOMIC POTENTIALS FOR OHIO CATTLE FEEDING

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Economic Potentials for Ohio Cattle Feeding

THOMAS T. STOUT and JAMES F. BERG

SUMMARY

There is a popular conviction among Ohio cattlemen that nearness both to population centers and to calf supplies gives Ohio feedlots some advantages in both fed markets and calf procurement which western lots cannot match. These advantages, it is believed, make up for any Ohio shortcomings which might be discovered by direct comparison of the feedlots themselves. This study sought to make these direct comparisons in the three critical areas of fed cattle markets, feedlot costs, and calf procurement.

Comparisons between Ohio and Texas did not disclose any apparent advantages for Ohio producers in fed cattle markets during the period examined. Comparison of feedlot operations showed average feedlot costs to be lower in Texas, but that efficient Ohio feedlots had costs comparable to large Texas lots. Fixed costs were lower in Texas lots; feed costs were lower in efficient Ohio lots. Comparisons indicated that Ohio feedlots have locational advantages in calf procurement, and suggested that these advantages could be greater if efforts were made to develop them.

A summary assessment of the competitive situation between Ohio and the Southern Plains would appear to be that for Ohio: 1) there are no apparent advantages in fed markets, but that 2) there are distinct advantages in feeder markets, and 3) these feeder advantages can be either confirmed or lost depending upon how an Ohio feedlot is run.

INTRODUCTION

The beef industry in the United States grew substantially during the decade of the 1960's. Per capita consumption of beef increased from 85.0 lb. in 1960 to 110.5 lb. in 1969.[1] Between January 1, 1960, and January 1, 1970, the total resident population of the nation increased from approximately 179 million to 203 million.[2] Beef consumption (excluding veal) therefore increased during the decade by about 6.1 billion lb. The increase in domestic beef production during this 10-year period amounted to about 6.4 billion lb.[3]

This growth in beef production during the 1960's was characterized by at least two continuing developments. One of these was the decline in the number of dairy cattle in the United States and the other was the dramatic increase in cattle feeding. Between 1960 and 1970, the January 1 inventory of dairy cattle on U. S. farms declined from 30.2 to 21.2 million head. Milk cows decreased from 19.6 to 13.9 million head. Beef cows on U. S. farms increased between these same two dates from 26.3 to 37.4 million head.[4] Fed cattle marketings in 26 states increased from 13.9 million head in 1960 to 24.2 million head in 1969.[5]

This growth brought a significant change not only to the quality of beef consumed but also to the structure of beef production during the decade. Fed cattle marketings in 1960 amounted to about 54 percent of commercial cattle slaughter, but accounted for 71 percent of commercial cattle slaughter in 1969.[6] By 1969, the number of fed cattle marketings exceeded the total number of steers and heifers slaughtered in that year. This does not mean necessarily that all steers and heifers were fed, because feeding was not confined to these market classes. The percentage of steers and heifers fed is conjectural, but it is undoubtedly high. One USDA estimate indicated that fed steers and heifers accounted for perhaps 84.3 percent of steer and heifer slaughter in 1968.[7] The figure may be too low.[8]

This increase in cattle feeding has characteristics which are disturbing to some Corn Belt cattle feeders. One of these is the extent to which much of the growth is occurring outside of traditional Corn Belt feeding areas. A second characteristic is the extent to which cattle feeding has become a commercial feedlot enterprise rather than the supplementary sort of activity typifying Corn Belt cattle feeding. A third development is the increasing extent to which cattle feeding is concentrated in the hands of few commercial feeders of very large size. By 1969, cattle feedlots with a capacity exceeding 1000 head accounted for only 1 percent of the total number of

[1]Consumption reported periodically in Livestock and Meat Situation, Economic Research Service, U. S. Department of Agriculture.

[2]Statistical Abstract of the United States, 1970. Bureau of the Census, U. S. Department of Commerce.

[3]Livestock and Meat Statistics. Annual supplements to SB 333, Economic Research Service, USDA. Differences between domestic production and consumption are due to military consumption and foreign trade.

[4]Ibid.

[5]Ibid. 1969 estimate includes 1968 data for Nevada, North Dakota, Utah, and Wyoming, for which 1969 data were not reported.

[6]Cattle slaughter reported in Livestock and Meat Statistics.

[7]Rizek, R. L. and J. T. Larsen. Oct. 1969. Our Beef Producing Potential. Livestock and Meat Situation, LMS-169, Economic Research Service, USDA.

[8]The percentage apparently was based on an estimate of fed cattle marketings from less than 39 states, for example.

TABLE 1.—Changes in U. S. Production of Selected Agricultural Products in Selected Census Years.

Production and Sales	1949	1954	1959	1964
	(Thousands)	(Thousands)	(Thousands)	(Thousands)
Turkeys				
Farms Reporting Sales	162	n.a.*	88	42
Sales (Head)	36,438	n.a.	80,396	104,750
Broilers				
Farms Reporting Sales	n.a.	50	42	35
Sales (Head)	n.a.	796,207	1,419,260	1,915,374
Milk				
Farms Reporting Sales	3,682	2,957	1,837	1,134
Sales (Lb.)	68,670	n.a.	97,606	105,996

*n.a.—Data not available.

Source: 1964 U. S. Census of Agriculture, Vol. II, Chapter 2. Census data for 1969 not available at publication date.

feedlots, but they produced more than half of the nation's output of fed beef.[9]

OBJECTIVES AND PROCEDURES

This study sought to determine:

1. Sources of feeder calves shipped into Ohio feedlots, and trends in the relative importance of these sources.
2. Feeder calf procurement cost differences from different sources.
3. Feedlot operating costs for operations reflecting the competitive economic potential for Ohio cattle feeding.
4. Prices received by cattle feeders for slaughter cattle.

The study did not investigate two possible aspects of cost initially contemplated for study.

1. Procurement cost differences due to variations in season of the year, methods of financing, livestock losses, and calf sex.
2. Differences in marketing costs and prices received for fed cattle due to differences in marketing channels and live-pricing accuracy as an indicator of carcass value.

Procedurally, three areas of direct comparison were sought between Ohio and Texas-Oklahoma cattle feeding operations. These were: 1) prices received for fed cattle, 2) feedlot operating costs, and 3) feeder calf procurement costs. Comparisons appear in that order in the following presentation. However, no analytical effort was devoted to a comparison of fed cattle prices in Ohio and the Southern Plains. Reported prices were accepted as a valid basis for comparision. The analytical thrust of this study is found in the analysis of feeder calf shipment patterns and feedlot operating costs.

[9]Packers and Stockyards Resume (Statistical Issue). Dec. 18, 1970. Packers and Stockyards Administration, USDA.

Actual shipment patterns of feeder calves into Ohio and Texas lots which are presented are based on records maintained in each state. Optimum interstate shipment patterns for the U. S. (which permit Ohio-Texas comparisons) were determined with transportation models.

Feedlot operating costs were determined by comparing published studies of feedlot operating costs in each state and by field work to obtain recent cost data to supplement previous Ohio studies. Such data were developed for 7,400 cattle in four participating feedlots which were selected with the expectation that they would represent the economic potential which could reasonably be expected of efficient Ohio feedlots.

The presentation which follows has been arranged to provide highlights of research results without burdening the reader with procedural considerations. Accompanying appendices provide procedural notes about the transportation models.

THE CHANGING COMPETITIVE ENVIRONMENT

Increasing Concentration of Production

The increasing concentration of production in American agriculture is well known. Crop and animal concentration figures drawn from the U. S. Census of Agriculture have been widely publicized. Turkeys, broilers, and milk production provide illustrations. For example, during the 15-year period 1949-1964, milk sales rose more than 50 percent although dairy farm numbers decreased nearly 70 percent; in the 10 years 1954-1964, broiler sales increased 140 percent while the number of producers, already highly concentrated, declined another 30 percent (Table 1).

Cattle production shared these same trends during the 1954-1964 decade. Most producers sold modest numbers of cattle in both years, but the mortality rate was most severe among small producers. Producer numbers declined from 1.9 to 1.4 million

during the decade and nearly all of the decline occurred among those individuals who sold less than 20 cattle. By 1964, 6,000 producers among 1.4 million accounted for nearly one-third of all cattle sales (Table 2).

Growth of Commercial Feedlots

Much of this change in cattle production is associated with the growth in cattle feeding and the emerged importance of large, commercial feedlots in the West North Central states and scattered non-Corn Belt locations, especially the Southern Plains. Between 1962 and 1969, fed cattle marketings from feedlots with more than 1,000 head annual capacity increased from 5.6 million head to approximately 12.7 million head in 32 principal cattle-feeding states, and the number of such feedlots increased from 1,517 to 2,181 (Table 3). During this same period, the marketings from these lots increased from approximately one-third to more than one-half of all fed cattle marketings. The output from feedlots of less than 1,000 head capacity fell proportionately, and the number of these relatively smaller lots declined from nearly 235,000 to less than 200,000.

Changing Regional Patterns of Cattle Feeding

The growth of cattle feeding outside the Corn Belt has been associated with factors such as the availability of feed grain and calf supplies, increased irrigation, the introduction of grain sorghum, and the substitution of sorghum for wheat.[10] In the period 1961-1969, sorghum grain production in the United States increased from 480 to 743 million bushels, and 85 percent of this production occurred in the four Plains states of Texas, Oklahoma, Kansas, and Nebraska.[11]

Comparative data for cattle feeding in 26 states in 1960 and 1969 record the impact of these developments on changing regional patterns of cattle feeding activity (Table 4). Cattle feeding increased in all regions, but at different rates. Proportionately, most growth occurred outside of the North Central Region. Between 1960 and 1969, cattle feeding increased 87.6 percent in all 26 states, but did not grow at quite this

TABLE 2.—Thousands of U. S. Farms Selling Cattle, Thousands of Cattle Sold, and Cattle Sold per Farm, Census Years, 1954 and 1964 (Calves Excluded).

Cattle Sold per Farm	Farms Selling Cattle		Total Sales, 1964	
	1954*	1964	Number	Percent
1-4	1,028	616	1,349	3.8
5-19	595	478	4,445	12.8
20-49	157	152	4,532	13.1
50-99	47	59	3,965	11.5
100-199	20	32	4,234	12.2
200 or More	12	17	4,833	14.0
500 or More†	—	6	11,248	32.6
Total All Farms	1,859	1,360	34,606	100.0

*Alaska and Hawaii not included.
†Applies only in 1964 when preceding interval was 200-499.
Source: 1964 U. S. Census of Agriculture, Vol. II, Chapter 2. Census data for 1969 not available at publication date.

[10]For example, see McCoy, J. H. and C. C. Hansman. April 1967. Economies of Scale in Commercial Cattle Feedlots of Kansas —Analysis of Nonfeed Costs. Tech. Bull. 151, Kansas Agricultural Experiment Station, Manhattan.

[11]Crop Production. Annual summaries for selected years, Statistical Reporting Service, USDA. Even more dramatic grain sorghum production increases occurred in the short period 1956-1961, rising from 206 to 480 million bushels in 5 years.

TABLE 3.—Number of Cattle Feedlots and Fed Cattle Marketings by Size of Feedlots, 32 Principal Feeding States, U. S., 1962-1969.

Year	Feedlots More Than 1,000 Head Capacity			Feedlots Less Than 1,000 Head Capacity		
	Number of Lots	Cattle Marketed (1,000 Head)	Percent of All Cattle Marketed	Number of Lots	Cattle Marketed (1,000 Head)	Percent of All Cattle Marketed
1962	1,517	5,572	36.5	234,646	9,689*	63.5
1963	1,579	6,118	37.6	230,825	10,156*	62.4
1964	1,668	7,050	38.9	223,071	11,094	61.1
1965	1,787	7,941	42.4	220,164	10,777	57.6
1966	1,921	9,026	44.3	215,296	11,336	55.7
1967	2,034	9,822	45.3	209,581	11,874	54.7
1968	2,080	10,823	47.0	206,516	12,217	53.0
1969	2,181	12,688†	51.5	198,200	11,957†	48.5

*Adjustments in total fed cattle marketings were made by the authors. Two estimating series report marketings before and after 1964. The early series reports 1962-64 marketings at 14.361, 15.314, and 17.074 million head. The later series reports 1964 at 18.144 million head, 6.27 percent higher. The authors have adjusted by 6.27 percent the 3 years in the older series to 15.261, 16.274, and 18.144 million head.
†Marketings from feedlots with more than 1,000 head were reported for only 22 states in 1969. Figures here include 1968 data for 10 states excluded from 1969 report. In the 22 states reported, feedlots with more than 1,000 head marketed 51.8 percent of total.
Sources: For fed cattle marketings in feedlots with less than 1,000 head in 1962-63, annual supplements to Livestock and Meat Statistics, Statistical Bulletin 333, SRS, USDA, July 1963. For all other 1962-1966 data, Number of Cattle Feedlots by Size Groups, SRS-14, Crop Reporting Board, SRS, USDA, July 1968. For 1967-69 data, Cattle on Feed, Crop Reporting Board, SRS, USDA, January issues, 1969 and 1970.

TABLE 4.—Thousands of Fed Cattle Marketed in 26 U. S. Cattle Feeding States, Percentage Distribution by States, and Percentage Change by Years, 1960 and 1969.

Region and State	1960 Fed Cattle Marketings	1960 Percent of U.S.	1969 Fed Cattle Marketings	1969 Percent of U.S.	Percent Change 1960-69
	(Thousands)		(Thousands)		
East North Central					
Illinois	1,225	9.7	1,216	5.0	—3.1
Indiana	293	2.3	511	2.1	74.4
Michigan	180	1.4	244	1.0	35.6
Ohio	287	2.2	434	1.8	51.2
Wisconsin	164	1.3	212	0.9	29.3
Total ENC	2,179	16.9	2,617	10.8	20.1
West North Central					
Iowa	2,565	20.0	4,618	19.2	80.0
Kansas	511	4.0	1,674	6.9	227.6
Minnesota	600	4.7	803	3.3	33.8
Missouri	440	3.4	731	3.0	66.1
Nebraska	1,434	11.1	3,322	13.8	131.7
North Dakota	178	1.4	118*	0.5	—33.7
South Dakota	362	2.8	551	2.3	52.2
Total WNC	6,090	47.4	11,817	49.0	94.0
Total NC	8,269	64.3	14,434	59.8	74.6
Other Feeding States					
California	1,595	12.4	2,057	8.5	29.0
Colorado	738	5.7	1,757	7.3	138.1
Oklahoma	143	1.1	496	2.0	246.9
Texas	477	3.7	2,706	11.2	467.3
10 Other States†	1,652	12.8	2,703*	11.2	63.6
Total (26 States)	12,874	100.0	24,153*	100.0	87.6

*1968 data have been used for Nevada, North Dakota, Utah, and Wyoming, for which 1969 data were not published.

†Includes Arizona, Idaho, Montana, Nevada, New Mexico, Pennsylvania, Oregon, Utah, Washington, and Wyoming.

Source: Livestock and Meat Statistics, Statistical Reporting Service, USDA, annual supplements to Statistical Bulletin No. 333.

TABLE 5.—Thousands of Feeder Calves Shipped into Ohio, Regional Percentage Distribution of Inshipments, and Percentage Change, 1961 and 1969.

Sources of Calves	1961 Number	1961 Percent	1969 Number	1969 Percent	1969 as Percent of 1961
All Southern	148.8	61.5	259.6	80.6	174.4
Kentucky	60.8	25.1	111.4	35.5	188.2
Virginia	40.0	16.5	52.4	16.3	131.0
Tennessee	26.4	10.9	44.8	13.9	169.7
North Carolina	1.6	0.7	18.6	5.8	1162.5
West Virginia	12.2	5.1	17.5	5.4	143.4
Other Southern	7.8	3.2	11.9	3.7	152.6
All Western	46.3	19.1	33.9	10.5	73.3
All Corn Belt	24.1	10.0	16.4	5.1	68.1
All Other States	22.8	9.4	12.1	3.8	53.1
Total Ohio Inshipments	242.0	100.0	322.0	100.0	133.1

Source: Ohio Crop Reporting Service.

rate in the 12 North Central states. Consequently, the share of total fed cattle marketings for the region declined during the period from 64.3 to 59.8 percent. Cattle feeding in the East North Central states increased only 20.1 percent, and the share of marketings from the region declined from 16.9 to 10.8 percent of the total.

Most rapid growth rates occurred in Colorado, Oklahoma, and Texas. These had a significant impact on regional patterns. For example, in 1960 Texas produced about as many fed cattle as Ohio and Michigan together. By 1969, however, Texas fed more cattle than all five states combined in the East North Central region (Table 4).

Changing Patterns of Feeder Calf Movements

This growth in regions not historically associated with cattle feeding has meant new demand for calves in those regions, and changes in historic feeder calf shipment patterns. The extent of this shift in calf movements is illustrated by the changing pattern of shipments into Ohio from other states (Table 5).

During the 1960's, the number of calves shipped into Ohio increased by one-third, but all of the increase came from southern sources. All non-southern sources of feeder calves declined in importance. By 1969, Ohio purchases of western calves were being made at about three-fourths of the 1961 level. Only two-thirds as many calves came from other Corn Belt states. Purchases from other scattered states were down to about one-half of their former levels (Table 5). The increase in calf purchases from Kentucky alone (50,600) more than made up for the decline in receipts from all non-southern sources (30,800).

TABLE 6.—Steer and Heifer Prices: Annual Average Price per Hundred Received by Farmers, Selected Areas, Selected Years, 1961-1969.

Year	East North Central Region	Ohio	West South Central Region	Texas
1961	$22.40	$21.50	$21.60	$21.80
1963	21.90	21.40	21.60	21.30
1965	22.40	22.40	21.00	21.00
1967	23.80	23.80	23.60	23.70
1969	27.90	28.00	28.40	28.60
Average	$23.68	$23.42	$23.24	$23.28

Source: Agricultural Prices, Crop Reporting Board, SRS, USDA, Annual Summaries.

ANALYSIS OF COMPETITIVE ASPECTS OF FED CATTLE FEEDING AND MARKETING

Fed Cattle Markets

Less analytical effort was devoted to a comparison of fed cattle markets than to feedlot costs or calf procurement. Comparisons which appear to be relevant are rather straightforward. Relative positions of producers in Corn Belt and Southern Plains markets should be reflected in prices received for products sold. Such prices are reported regularly by the U. S. Department of Agriculture (Table 6).

Ohio serves the East Coast market and the Southern Plains is more related to the growing West Coast market. Farm prices in Ohio and Texas are all part of one national system, but they are directly backed off from different coastal centers.

While there is more slaughter capacity in Ohio than Ohio cattlemen can use, providing a multitude of competitive market alternatives, there also is no significant restriction on slaughter capacity in the

TABLE 7.—Federally Inspected Slaughter Plants and Commercial Cattle Slaughter, by Census Regions, 1960 and 1969.

Census Region	Plants Under Federal Inspection		Commercial Cattle Slaughter				
			1960		1969		Percent Change 1960-1969
	1960 Number	1969 Number	Number	Percent	Number	Percent	
			(Thousands)		(Thousands)		
North Atlantic	87	85	1,933.9	7.7	1,663.3	4.7	—14.0
East North Central	107	111	4,977.0	19.7	5,097.0	14.5	2.4
West North Central	108	147	8,765.7	34.9	14,275.9	40.4	62.9
South Atlantic	41	56	1,273.2	5.0	1,347.6	3.8	5.8
South Central	35	46	1,422.0	5.6	1,781.1	5.1	25.3
West South Central	33	80	1,825.9	7.2	3,724.5	10.6	104.0
West	119	179	5,026.6	19.9	7,347.5	20.9	46.2
U. S. (48 states)	530	704	25,224.3	100.0	35,236.9	100.0	39.7

Source: Derived from the following publications: Anthony, Willis E. Feb. 1966. Structural Changes in the Federally Inspected livestock Industry, 1950-62, Agricultural Economic Report No. 83, Economic Research Service, USDA; Livestock Slaughter, Crop Reporting Board, Statistical Reporting Service, USDA, April 1969; and Livestock and Meat Statistics, Statistical Reporting Service, USDA, annual supplements to Statistical Bulletin 333.

Southern Plains, where slaughter facilities have expanded rapidly. During the 1960's, Federal inspected (FI) slaughter increased more rapidly in the West South Central states (which includes Texas) than in any other region of the country. While FI slaughter increased only 2.4 percent during the decade in the East North Central states, FI slaughter in the West South Central region increased 104.0 percent (Table 7).

A result of these considerations is that steer and heifer prices received by West South Central producers tended to improve during the 1960's relative to their East North Central counterparts. During the 1960's, prices received by producers in Texas were comparable to prices received in Ohio (Table 6).

If prices received are a satisfactory indicator, then it appears that Ohio cattlemen enjoy no singular advantages in fed cattle markets. Competitive advantages or disadvantages which may be associated with feedlot activity in either location would seem therefore to be confined to feeder calf procurement costs and to total costs of operating feedlots in either location. Much of the analytical effort reported in this bulletin is a comparative examination of these competitive aspects.

Feedlot Operating Costs

Fixed and Variable Costs: Most operators are aware that two kinds of costs are involved in running an enterprise—fixed costs and variable costs.[12]

The most important variable cost of operating a feedlot is feed. Variable costs have two characteristics. 1) They vary in *total* amount depending on whether the operation is large or small. The annual feed bill is large or small depending upon whether many or few cattle are fed in the course of a year. 2) However, the cost of an optimum feed ration per pound of gain does not vary with variations in the number of cattle fed. Feed cost per pound of gain does not decline as the operation grows. For example, if feed cost per pound of gain were higher in the Southern Plains than in the Corn Belt, southern feedlots would not be competitive on a feed-cost basis with the Corn Belt, and bigger southern feedlots would not solve the problem. Some other costs would have to be lower.

Fixed costs of an enterprise are the costs incurred when the physical structure is erected and the investment is committed to a purpose spanning a period of years. Fences, feedbunks, aprons, silos, and other integral and long-term investments in a feedlot facility constitute the fixed costs of the venture. The characteristics of fixed costs are that: 1) no matter how much or little volume is moved through the fixed facility, the annual bill of costs for that facility (rent, interest, depreciation, etc.) remains essentially constant; and 2) as more volume is moved through the facility, the cost per unit declines. Volume could of course be pushed too far, to a point for example that costs of physical deterioration and damage mounted rapidly.

Optimum capacity might be regarded as that capacity at which fixed costs per unit (fixed costs per pound of gain) are minimized and profit maximized. Large commercial feedlots in the Southern Plains provide an illustration. When many thousand cattle are on feed at a given time, in low-cost unsheltered enclosures, fixed costs per pound of weight gained can be very low indeed, and normally much lower than in a typical Corn Belt supplementary feeding enterprise.

Fixed Costs Comparisons: Despite small volume compared to feedlots in the Southern Plains, the present study as well as an earlier work by Blosser confirm that effectively managed Ohio feedlots produced beef during the years studied at total costs comparable to those recorded by Dietrich in his investigation of Texas-Oklahoma feedlots (Table 8). There also were evident differences in fixed and variable cost structures between Ohio and Southern Plains feedlots. Fixed costs of Ohio feedlots were determined by Blosser from participating farm account records; in the present study they were determined by standard farm appraisal techniques.

Fixed costs in both Ohio studies were two to three times higher than those recorded by Dietrich in 1966-67, approximating 2.5¢ to 2.9¢ per pound of gain in Ohio compared to 1.0¢ to 1.5¢ in Texas-Oklahoma (Table 8). Little of this cost difference would be attributable to differences in feedlot utilization; Ohio and Southern Plains lots all experienced similar average utilization rates (Table 8).[13] Low fixed costs in Southern Plains lots are associated with economies of very large scale operations which are unavailable to Ohio feedlot operators. Scale economies of Ohio and Southern Plains lots are compared in Figures 1 and 2.

Variable Costs Comparisons: Paralleling the Dietrich study, variable costs in Ohio feedlots were recorded in feed and non-feed categories. Non-feed

[12]Sometimes farmers and other businessmen refer to fixed costs as "overhead" costs, and variable expenses frequently are referred to as "out-of-pocket" costs.

[13]Degree of feedlot capacity utilization was determined by the equation:

Feedlot Utilization = (Turnover Ratio) (Average Days on Feed)

where:

$$\text{Turnover Ratio} = \frac{\text{Number of Cattle Fed Annually}}{\text{Feedlot Capacity}}$$

Ohio feedlots typically have a small turnover ratio and a large number of days on feed. Southern Plains feedlots typically feed a smaller number of days and generate a high turnover ratio.

TABLE 8.—Costs per pound of Gain by Cattle in Ohio and Texas-Oklahoma Feedlots, Selected Years, 1963-1969.

Source of Data	Average Costs per Pound of Gain (Dollars)				Percent Capacity Utilized
	Variable Costs		Fixed Costs	Total	
	Feed	Non-feed			
Ohio Field Work*					
1968-1969 Results	0.1963	0.0432	0.0288	0.2683**	67.9
Best Results	0.1641	0.0370	0.0251	0.2262**	—
Ohio Farm Accounts†					
1963-1964 168 Farms	0.1785	0.0449	0.0478	0.2512**	69.3
Best 56 Farms	0.1423	0.0348	0.0216	0.1987**	—
Texas‡					
1966-1967 Average Feedlots More Than 10,000 Head	0.1755	0.0409	0.0118	0.2282	73.0
	0.1764	0.0373	0.0098	0.2235	77.6
Oklahoma‡					
1966-1967 Average Feedlots More Than 10,000 Head	0.1873	0.0455	0.0147	0.2475	69.1
	0.1851	0.0444	0.0128	0.2420	78.6

*Original data, present study: 7,400 head.
†Blosser, R. H. April 1969. Costs of Feeding Cattle in Ohio, Res. Circ. 165, OARDC: 39,822 head.
‡Dietrich, R. A. May 1969. Costs and Economies of Size in Texas-Oklahoma Cattle Feedlot Operations, Bull 1083, Texas Agricultural Experiment Station. Study included 70 percent of all cattle fed in Texas, July 1966 through June 1967.
**Undeflated dollars. Differences between 1963-64 and 1968-69 results reflect inflationary price increases, mostly feed.

variable costs included labor, utilities, veterinary expenses, and similar smaller items which were related directly to volume of operation. Non-feed costs of this nature were similar in Ohio and in the Southern Plains, approximately 3.5¢ to 4.5¢ per pound of gain in both locations (Table 8). Thus, both the Blosser study and the present study found that Ohio feedlots compare unfavorably with Texas-Oklahoma lots in terms of fixed costs. An examination of non-feed variable costs also disclosed no counterbalancing advantage to overcome fixed cost disadvantages (Table 8). Hence the opportunity for producing the necessary saving to offset these disadvantages fell to the feeding program.

Participating Ohio feedlots showed feed costs averaging 1¢ above Oklahoma and 2¢ above Texas costs. As a consequence, average *total* costs per pound of gain in Ohio were 1¢ to 5¢ above average Texas-Oklahoma costs (Table 8). Under these circumstances, Ohio feedlot operators would not be able to survive in the long run in competition with the Southern Plains.

There was variation from this average, however, and some operations registered feed costs low enough to offset fixed cost disadvantages and yield total costs per pound of gain competitive with reported Texas-Oklahoma costs (Table 8). In terms of feed cost per pound of gain, steer calves showed the best performance among 7,400 cattle for which records were kept during 1968-69. Yearlings registered higher daily rates of gain, but not enough to compensate for higher daily feed consumption. Heifer calves compared unfavorably with either steers or yearlings in both rate of gain and feed cost per pound of gain (Table 9). All feeding programs were based on corn silage and concentrate feed rations.

The best individual enterprise results for feed costs in 1968-1969 were recorded on approximately 1,500 calves (one-third heifers) in three lots which had a feed cost of 16.41¢ per pound of gain. The

TABLE 9.—Daily Rates of Gain and Feed Cost per Pound of Gain by Weight and Sex, 7,400 Feeder Cattle, Ohio, 1968-69.

Number and Class	Average Purchase Weight	Average Sale Weight	Average Daily Rate of Gain	Average Feed Cost per Pound of Gain
	(Lb.)	(Lb.)	(Lb.)	(Cents)
1,144 Yearling Steers	786.0	1080.2	1.917	21.04
1,897 Heifer Calves	498.1	816.1	1.555	21.54
4,359 Steer Calves	418.3	942.9	1.777	18.81
7,400 Total				

Source: Original data.

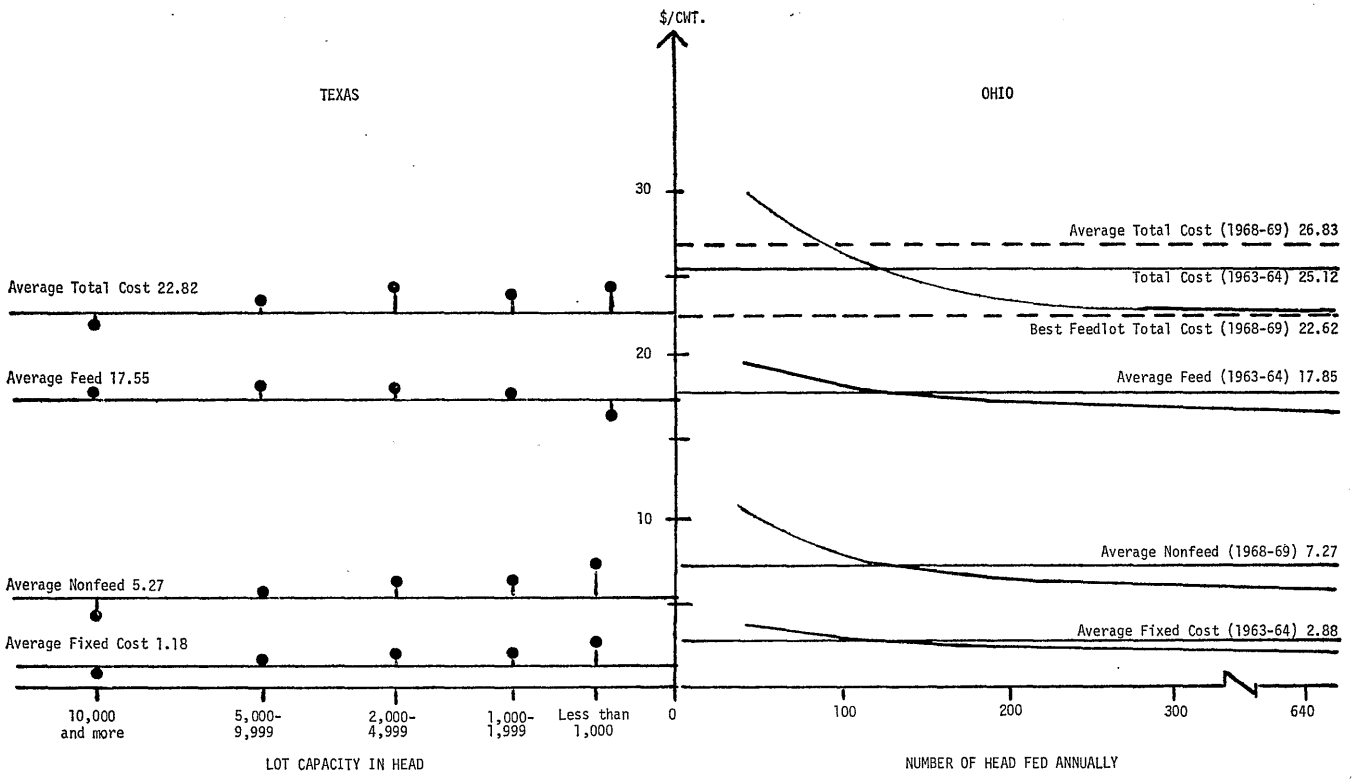


FIG. 1.—Comparative feeding costs, Texas and Ohio.

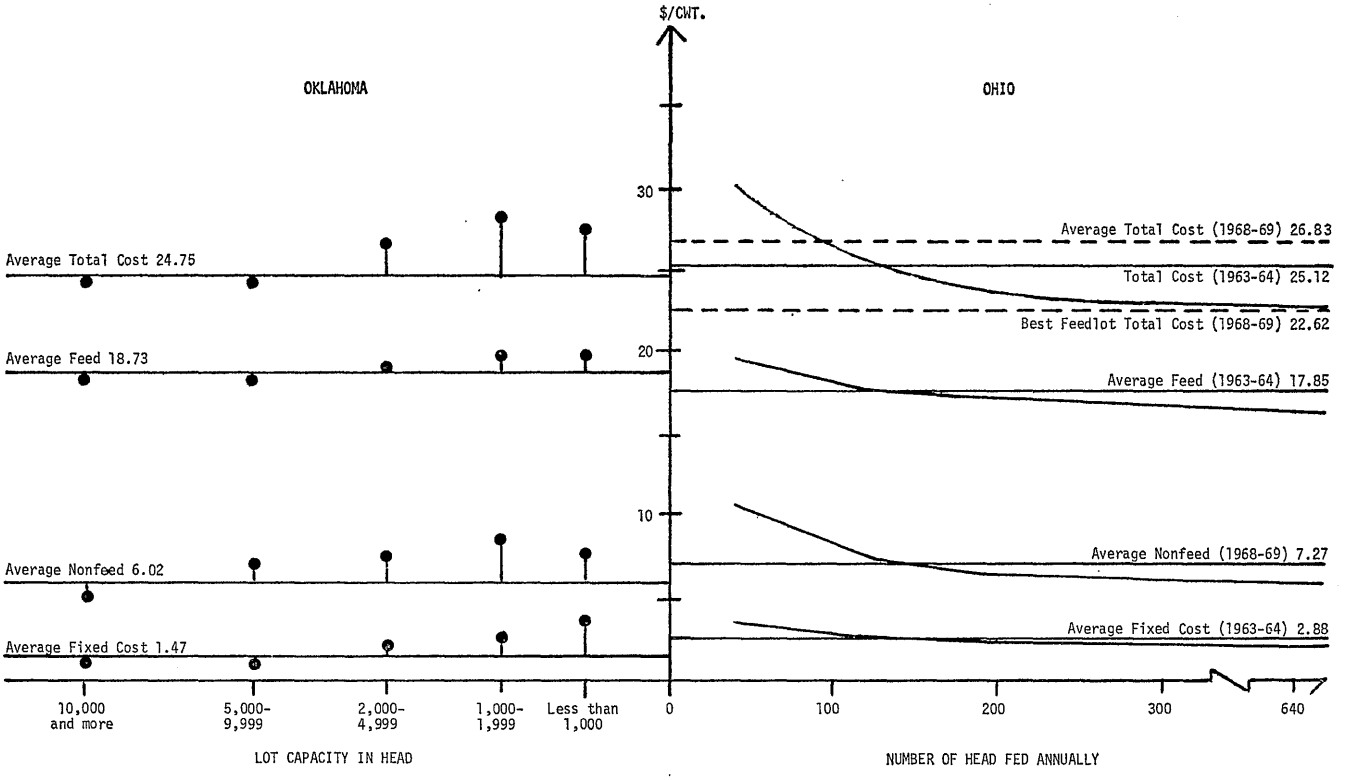


FIG. 2.—Comparative feeding costs, Oklahoma and Ohio.

best individual group of calves among 7,400 was a group of 212 steers fed 292 days from 441 to 976 lb., gaining 1.83 lb. per day and yielding a feed cost of 15.26¢ per pound of gain.

In brief summary, the Blosser study and the present analysis record fixed costs for Ohio feedlots which are higher than reported Texas-Oklahoma fixed costs. Moreover, Ohio feed costs often are higher. When this occurs, Ohio feedlots incur production expenses too costly to permit continued competition in the long run.

Effective competition requires total production costs no higher than occur in other major producing areas. To accomplish this, Ohio feedlot operators, lacking the cost-reducing economies of very large-scale operations, must concede a fixed cost disadvantage and offset it with compensatory savings in the feed program. The evidence indicates that this can be done, due perhaps to basic advantages in feed grain production (sorghum vs. corn) enjoyed by the Corn Belt.

The apparent competitive situation between Ohio and the Southern Plains might reasonably be described as one in which Southern Plains feedlots offset some disadvantages in variable feed costs by reducing fixed costs with large size, thereby realizing economies of scale. Ohio feedlots press their advantages in feed costs in order to offset disadvantageous fixed costs associated with small-scale feeding operations.

Differences in average and lowest feedlot costs per pound of gain in Ohio were large. Most of these differences were found in feed costs. Obviously, there are inefficiencies in Ohio feedlot operations. Ohio operations which can overcome these inefficiencies by avoiding elaborate facilities which add unnecessarily to fixed costs, and by attentive control of the feed budget, should be able to survive intense interregional competition in feedlot operations.

ANALYSIS OF CALF PROCUREMENT PATTERNS

Ohio-Texas Comparisons

Comparisons were made between feeder calf procurement patterns in Ohio and Texas. The comparisons were made both on the basis of estimated actual shipments reported by many states and on the basis

TABLE 10.—Transportation Costs for Ohio Inshipments: Representative Transportation Rates and the Transportation Bill for Feeder Cattle Inshipments, 1961, 1965, and 1969.

State of Origin	Per Cwt.	Per Head	1961	1965	1969
	(Dollars)		(Thousand Dollars)*		
Kentucky	0.38	1.90	115.5	183.9	217.4
Tennessee	0.73	3.65	96.4	104.8	163.5
Virginia	0.59	2.95	119.2	120.7	154.6
West Virginia	0.38	1.90	23.2	25.1	33.3
Alabama	1.07	5.35	28.9	160.5	48.7
Mississippi	1.42	7.10	—	83.1	19.9
Florida	1.82	9.10	18.2	20.9	—
North Carolina	0.92	4.60	7.4	27.6	85.6
South Carolina	1.03	5.15	—	8.8	—
Texas	2.24	11.20	116.5	149.0	87.4
Oklahoma	1.69	8.45	136.9	87.0	31.3
Kansas	1.57	7.85	54.2	50.2	55.0
Colorado	2.28	11.40	22.8	52.4	124.3
North Dakota	2.68	13.40	81.7	59.0	—
Montana	3.06	15.30	39.8	—	—
Indiana	0.38	1.90	39.5	27.0	16.7
Illinois	0.67	3.35	11.1	9.7	6.7
Minnesota	1.70	8.50	—	23.8	23.8
Missouri	1.70	8.50	—	—	23.8
Pennsylvania	0.99	4.95	10.4	26.2	22.3
Wisconsin	0.68	3.40	13.3	—	—
Total			935.0	1,219.7	1,114.3
Total Reported Inshipments (Thousand Head)			242.0	306.0	322.0
Unidentified Inshipments (Thousand Head)			18.9	10.5	12.1
Identified Inshipments (Thousand Head)			223.1	295.5	309.9
Transportation Cost per Head			$4.19	$4.13	$3.60

*All costs based on 500 lb. animals.

Source: Based on Shipments of Feeder Cattle into Ohio from Other States, Ohio Crop Reporting Service, and on transportation rates used in optimum shipment patterns, Appendix A.

TABLE 11.—Transportation Costs for Texas Inshipments: Representative Transportation Rates and the Transportation Bill for Feeder Cattle Inshipments, 1962, 1965, and 1967.

State of Origin	Per Cwt.	Per Head	1962	1965	1967
	(Dollars)		(Thousand Dollars)*		
Alabama	1.51	7.55	244.7	417.0	333.7
Arizona	1.55	7.75	6.1	49.3	12.3
Arkansas	.90	4.50	79.1	80.5	111.8
California	2.29	11.45	1.8	13.6	8.2
Colorado	1.18	5.90	67.1	55.6	66.8
Florida	2.29	11.45	855.4	356.6	321.3
Georgia	1.79	8.95	11.6	46.9	49.8
Illinois	1.64	8.20	13.3	8.9	10.1
Iowa	1.30	6.50	20.9	38.8	47.4
Kansas	.81	4.05	25.8	35.4	36.4
Louisiana	.85	4.25	379.9	468.9	229.9
Mississippi	1.06	5.30	255.5	409.7	652.6
Missouri	1.27	6.35	32.7	22.5	47.1
Montana	2.50	12.50	65.3	9.0	4.0
Nebraska	1.25	6.25	7.8	11.0	6.1
New Mexico	1.04	5.20	1,021.9	1,435.4	2,060.9
Oklahoma	.59	2.95	153.0	264.7	483.4
South Dakota	1.79	8.95	4.1	23.0	6.6
Wisconsin	2.01	10.05	24.4	38.3	84.5
Wyoming	1.37	6.85	7.1	7.7	17.6
Total			3,277.5	3,792.8	4,590.5
Total Reported Inshipments (Thousand Head)			557.8	717.4	910.3
Unidentified Inshipments (Thousand Head)			6.7	8.2	18.6
Identified Inshipments (Thousand Head)			551.7	709.2	891.7
Transportation Cost per Head			$5.95	$5.35	$5.15

*All costs based on 500 lb. animals.

Source: Based on inshipment data from the Texas Animal Health Commission, tabulated from health certificates, and on transportation rates used in optimum shipment patterns, Appendix A.

of estimated optimal shipment patterns determined by econometric analysis.

Tables 10 and 11 summarize actual shipments into Ohio and Texas for selected years as reported by the Ohio Crop Reporting Service and the Texas Animal Health Commission. Freight costs appearing in these tables are a combination of reported costs and costs estimated by methods described in Appendix A.

TABLE 12.—Procurement Costs (Freight and Shrink) on 500 Lb. Calves into Ohio and Texas Feedlots, 1968-1969.

Procurement Cost	Ohio	Texas
Under Actual (Reported) Shipment Conditions (1969)		
Average Miles Hauled	331.5	413.9
Freight per Head	$3.06	$3.82
Shrink per Head, Lb.	29.9	41.0
Under Estimated Optimum Shipment Conditions (1968)		
Average Miles Hauled	176.6	341.3
Freight per Head	$1.63	$3.15
Shrink per Head, Lb.	18.9	29.9

Source: Distances and rates for actual shipments derived from reported data. Optimum shipments determined by statistical analyses. Shrinkage based on Tippets. Feb. 1957. In-Transit Shrinkage of Cattle, Circular 78, University of Wyoming.

Both tables reflect a shipment trend toward the optimal pattern prescribed by transportation model analysis. Inshipment trends in other states not reported here also indicated a trend toward the optimal pattern. Deviations from an optimum pattern will continue to persist, however, due to continuing imperfections not taken into account by least cost models. These include conditions such as short and long-run market price imperfections, advantageous freight rates derived from backhauls, and traditional preferences for calves of particular grade, sex, breed, and origin.

A generalized statement of the results of the Ohio-Texas comparative analysis of procurement costs appears in Table 12. Under actual shipment conditions reported in 1969, calves were shipped an average distance of nearly 415 miles to reach Texas feedlots and slightly more than 330 miles to reach Ohio feedlots. Calves shipped into Ohio feedlots traveled about 80 percent of the distance required to move calves into Texas lots. These distances were associated with transportation and shrinkage costs which also were proportionately smaller for Ohio receipts. Ohio transportation costs were about 80 percent of Texas costs; shrinkage losses on Ohio ship-

ments were about 25 percent lower than those incurred on Texas shipments. Such comparisons identify a locational advantage in calf procurement enjoyed by Ohio feedlot operators.

Moreover, this advantage to Ohio feedlot operators would be greater under an optimum pattern of interregional feeder calf shipments. Both Ohio and Texas would benefit from a more optimal flow of feeder calf movements, but the relative advantage for Ohio feedlot operators would be increased. Under the estimated optimum shipment conditions, shipments into Ohio feedlots would have moved only about half the distance required of shipments into Texas lots. Associated costs of transportation and shrinkage would have been correspondingly lower (Table 12). The interregionally competitive nature of the feeder calf market suggests that over time the interstate shipment of calves will move in the direction of the optimum pattern.

National Comparisons

Transportation models, a method of linear programming, were used to develop an optimal (least-cost) national pattern of calf shipments among 40 regions of the United States. The model requires the establishment of regional boundaries, the determination of supply and demand for calves in each region, and the determination of freight rates between selected basing points in all regions. The shipment pattern generated by the model is optimal in the sense that the pattern minimizes total transportation costs. Methods and sources used in developing this information are summarized in accompanying appendices.

Previous studies of interregional calf movements have been limited to potential domestic beef calf supplies available for feeding.[14] The present analysis affords several advantages permitting a more detailed and accurate appraisal of optimum conditions. For example, 1) imports from several points in Canada and Mexico are included in the analysis, 2) dairy calves are included in total supply, 3) the identity of beef and dairy calves is separately maintained, 4) both dairy and beef calves are optimally allocated to competing feedlot and slaughter demands, 5) feeder calves and slaughter calves move at different weights,[15] 6) the role of nonfed cattle is acknowledged, and 7) transshipments occur, i.e., individual regions simultaneously occupy both import and export roles.

All of these characteristics underlie the optimal shipment patterns identified for feeder and slaughter calves in Figures 3 and 4. Both figures reveal frequent transshipments. Figure 3, for example, shows substantial import-export activity occurring in Arizona, Kansas, Nebraska, Nevada-Utah, Oklahoma, Oregon, Wyoming, and many other regions in the East and South. To a smaller extent, the same phenomena occurred in the simpler pattern of slaughter calf movements shown in Figure 4.

The total feeder calf procurement picture was dominated by shipments received in Iowa, the largest net deficit region in the nation. A generalized movement was evident for beef and dairy calves moving into Iowa from roughly the central third of the nation. So forceful was the movement that transshipments in the direction of Iowa became common in many of the surrounding states, like iron filings aligned toward a magnetic pole. California exerted a similar attraction in the West. There was no comparable central attraction in the East.

Ohio feedlot operators optimally obtained 217,000 beef calves and 17,000 dairy calves from within the state, exported 180,000 dairy calves to feedlots in Michigan, and imported 321,000 beef calves from Kentucky and 15,000 from West Virginia. Ohio slaughtered 84,000 local dairy calves and exported another 1,000 for slaughter in New York (Figure 4).

Other Corn Belt states were identified as major competitors with Ohio for the southern calf supply. Virginia calves optimally moved to Pennsylvania feedlots and Virginia imported nearly as many feeder calves as it shipped out. States in the Deep South did not typically sell to distant markets. Most calves in those states were shipped to other nearby Southern states which subsequently transshipped to Corn Belt destinations. A detailed account of these national shipment patterns and accompanying freight costs appears in Appendix Table II.

[14]For example, see Bowser, M. F., and J. W. Goodwin. June 1968. Optimum Distribution Patterns for Feeder Cattle. Tech. Bull. T-123, Oklahoma State University, Stillwater; and Buchholz, H. E. and G. G. Judge. Sept. 1965. An Interregional Analysis of the Feed-Livestock Economy. AERR 75, Illinois Agricultural Experiment Station, Urbana.

[15]Feeder calf weights were arbitrarily set at 500 lb. Slaughter calf weights were set at 230 lb., an average slaughter weight according to USDA data. It can be shown that allocation on a cost per hundredweight basis will yield the same result when calculated on a cost per head basis using two different weight calculations.

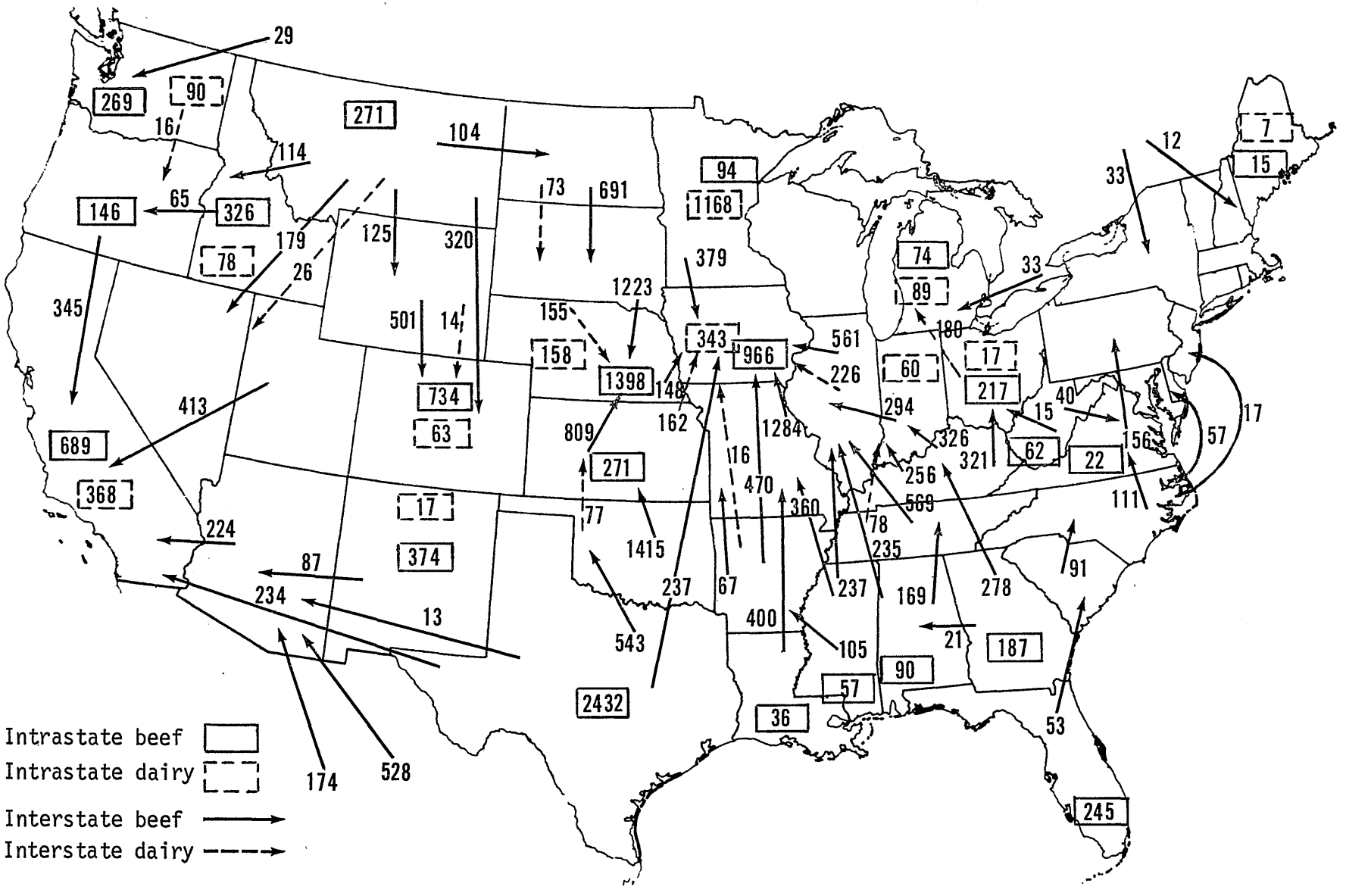


FIG. 3.—Optimal shipment patterns for feeder cattle, 1968 (1,000 head).

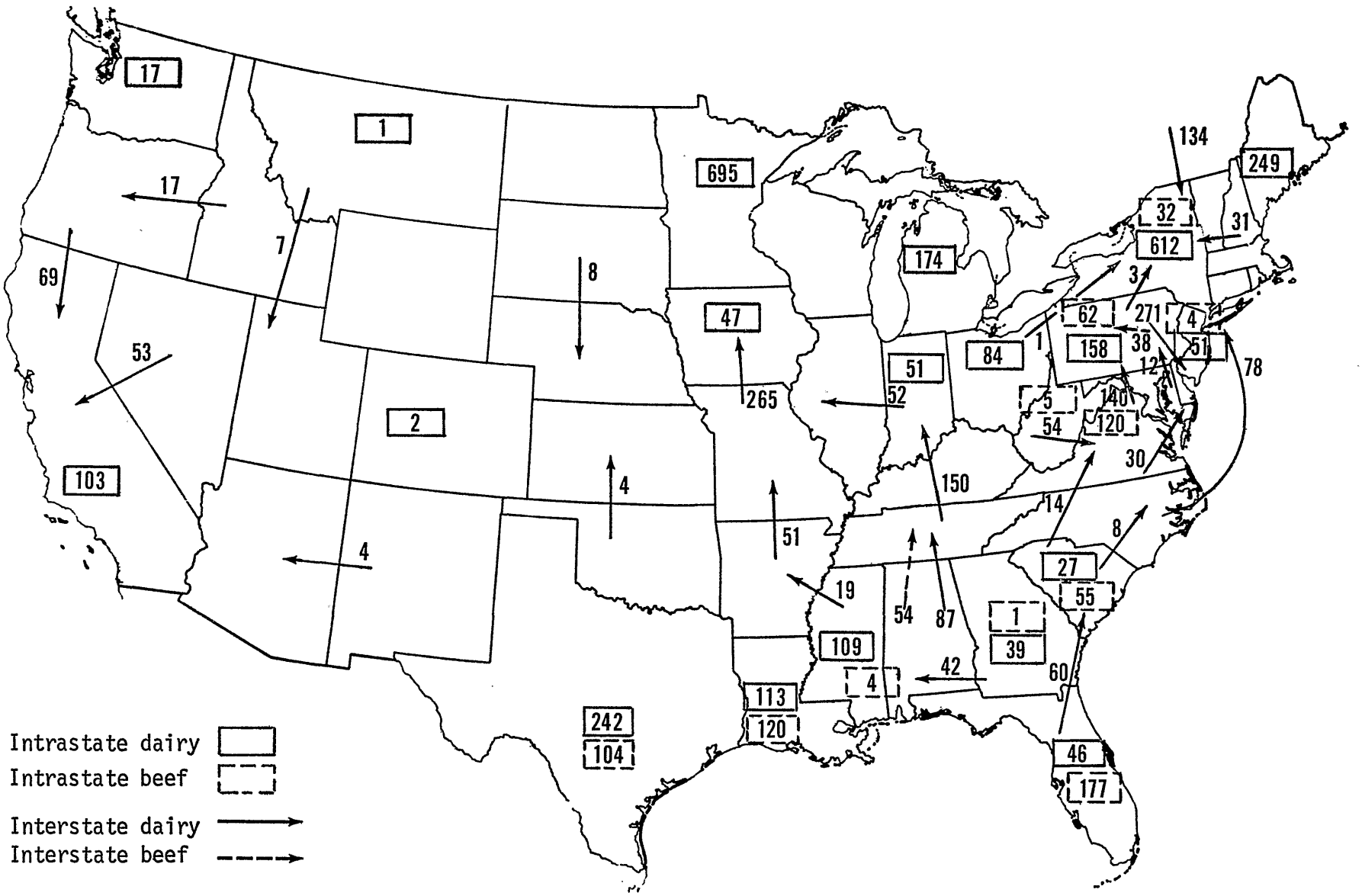


FIG. 4.—Optimal shipment patterns for slaughter calves, 1968 (1,000 head).

CONCLUSIONS

1. Cattle feeding is undergoing structural and regional changes. Many large commercial feedlots have developed in areas outside of traditional Corn Belt feeding areas.

2. Cattle feeding in Ohio increased more than 50 percent between 1960 and 1969, but the national average increase for 26 principal cattle feeding states during those same years was nearly 88 percent.

3. During 1960-1969, cattle feeding in all 12 North Central states increased 75 percent. But the regional percentage of total U. S. cattle feeding (26 states) dropped from 64.3 to 59.8 percent during the period.

4. The most rapid growth in cattle feeding occurred in the Southern Plains. Texas cattle feeding increased 467 percent from 1960 to 1969, from less than 4 percent to more than 11 percent of the 26-state supply. By 1969, Texas produced more fed cattle than all five East North Central states combined (Illinois, Indiana, Michigan, Ohio, and Wisconsin).

5. National feeder calf shipment patterns have been altered due to the growth of cattle feeding in new regions. One consequence of this is that Ohio feedlot operators buy fewer western calves and more southern calves. Between 1961 and 1969, western sources dropped from 19 percent to 10 percent of all calf shipments into Ohio, while southern sources increased from 61 percent to 81 percent.

6. On average, feedlots in the Southern Plains produced fed beef at lower costs than Ohio feedlots in years which were compared in the 1960's. A 1963-1964 Ohio study showed average Ohio feedlot costs of 25¢ per pound of gain. The present study showed costs in selected large Ohio feedlots averaged 26.8¢ per pound of gain. A Texas-Oklahoma study showed average feedlot costs of 22.8¢ to 24.8¢ per pound of gain in 1966-1967.

7. Southern Plains feedlots had lower fixed costs than Ohio feedlots. This relationship is likely to remain, due to the very large size of Southern Plains lots.

8. Effectively managed Ohio feedlots had lower variable costs than Southern Plains lots. This was accomplished by minimizing feed costs per pound of gain. When this occurred, Ohio feedlots produced fed beef as cheaply as Southern Plains lots. Average Ohio feedlots studied did not accomplish this. Study results imply that both the incentive and the opportunity are present for improved management of Ohio feedlots.

9. It is possible for Ohio feedlots to compete with Texas-Oklahoma feedlots if every effort is made to manage effectively and to minimize costs. Ohio studies show minimum costs per pound of gain of 19.9¢ (1963-1964) to 22.6¢ (1968-1969) compared to Texas-Oklahoma costs in feedlots more than 10,000 head of 22¢ to 24.2¢ per pound of gain (1966-1967).

10. Analysis of actual calf shipments in 1969 showed that Ohio feedlots enjoyed some advantage over Texas feedlots in calf procurement costs as reflected in shipping distance, freight costs, and shrinkage. Average distance on calves shipped into Ohio feedlots was 332 miles, compared to 414 miles into Texas lots. Freight into Ohio lots averaged $3.06 compared to $3.82 into Texas lots. Shrink was approximately 30 lb. in Ohio vs. 41 lb. in Texas.

11. Analysis of optimum shipment patterns of feeder calves indicated that shipping distance, freight costs, and shrinkage could be reduced on shipments into both Ohio and Texas feedlots. But reductions would be greatest into Ohio feedlots. Average shipping distances were 177 miles into Ohio lots compared to 341 miles into Texas lots. Freight would approximate $1.63 into Ohio and $3.15 into Texas lots. In the optimal shipment model, Kentucky and West Virginia appeared as optimal sources of calves for Ohio feedlots.

APPENDIX A

Optimum Shipment Patterns for Calves

Difficulties which must be overcome in determining an optimum shipment pattern for feeder calves are found in the complexity of calf movements. These are due largely to multiple transfers of ownership between origins and destinations, and in associated limits to published data which inadequately record these complexities. Estimating techniques are outlined in this and accompanying appendices.

The Basic Model

Transportation models were used to determine optimum shipment patterns between 46 regions of the United States.[16] Intrastate as well as interstate shipments were determined. Slaughter calf shipments were determined separately from feeder calf shipments. The identities of beef and dairy calves were maintained separately. Inshipments from Canada and Mexico were included in the analyses. Data published by the USDA and the Census of Agriculture provided the basic information. Required additional estimates conformed to the published series. An overview of the analytical approach appears in Appendix Figure I.

The transportation model determines optimal shipment patterns for transfer of feeder or slaughter calves from surplus to deficit regions in a manner minimizing the total transportation bill. Data requirements include quantities available for shipment from surplus regions, quantities required by deficit regions, and transportation costs between specified shipment points in each region.

A form of linear programming model, transportation models were first formulated by Hitchcock in 1941.[17] Expressed mathematically, the model is as follows:[18]

Minimize

$$T = \sum_{i=j}^{m} \sum_{j=i}^{n} C_{ij} X_{ij} \qquad (1)$$

subject to the conditions:

$$\sum_{i=j}^{m} X_{ij} > D_j \quad j = 1, 2, 3, \ldots, n \qquad (2)$$

$$\sum_{j=i}^{n} X_{ij} < S_i \quad i = 1, 2, 3, \ldots, m \qquad (3)$$

$$\sum_{i=1}^{m} S_i = \sum_{j=1}^{n} D_i \qquad (4)$$

in which, in equation

(1), T is the total transportation bill to be minimized;

(2), X_{ij} represents a shipment from any surplus (i) to any deficit (j) region, and D_j is the number of cattle to be received by any region (j);

(3), S_i is the number of cattle available for shipment from any region (i); and

(4), available supply from surplus regions (i) is equal to total demand from deficit regions (j).

What emerges from the analysis is a tableau depicting the optimum combination of shipments from surplus to deficit regions, as follows:

Origins	Destinations						
	1	2	3	. . . .	n		Total
1							S_1
2							S_2
3							S_3
.							.
.							.
.							.
m							Sm
Total	D_1	D_2	D_3	. . . .	D_n	$\sum_{i=j}^{m} S_i = \sum_{j=i}^{n} D_j$	

Each row corresponds to one of the m equations in equation (2) and each column represents one of the n equations in equation (3). A specific C_{ij} (transfer cost) is associated with each possible shipment. The transportation model forms a system of $m + n$ linear equations in mn unknowns, but the optimal solution is obtained by at most $m + n - 1$ positive shipments and total cost is at a minimum.

Analytical Assumptions

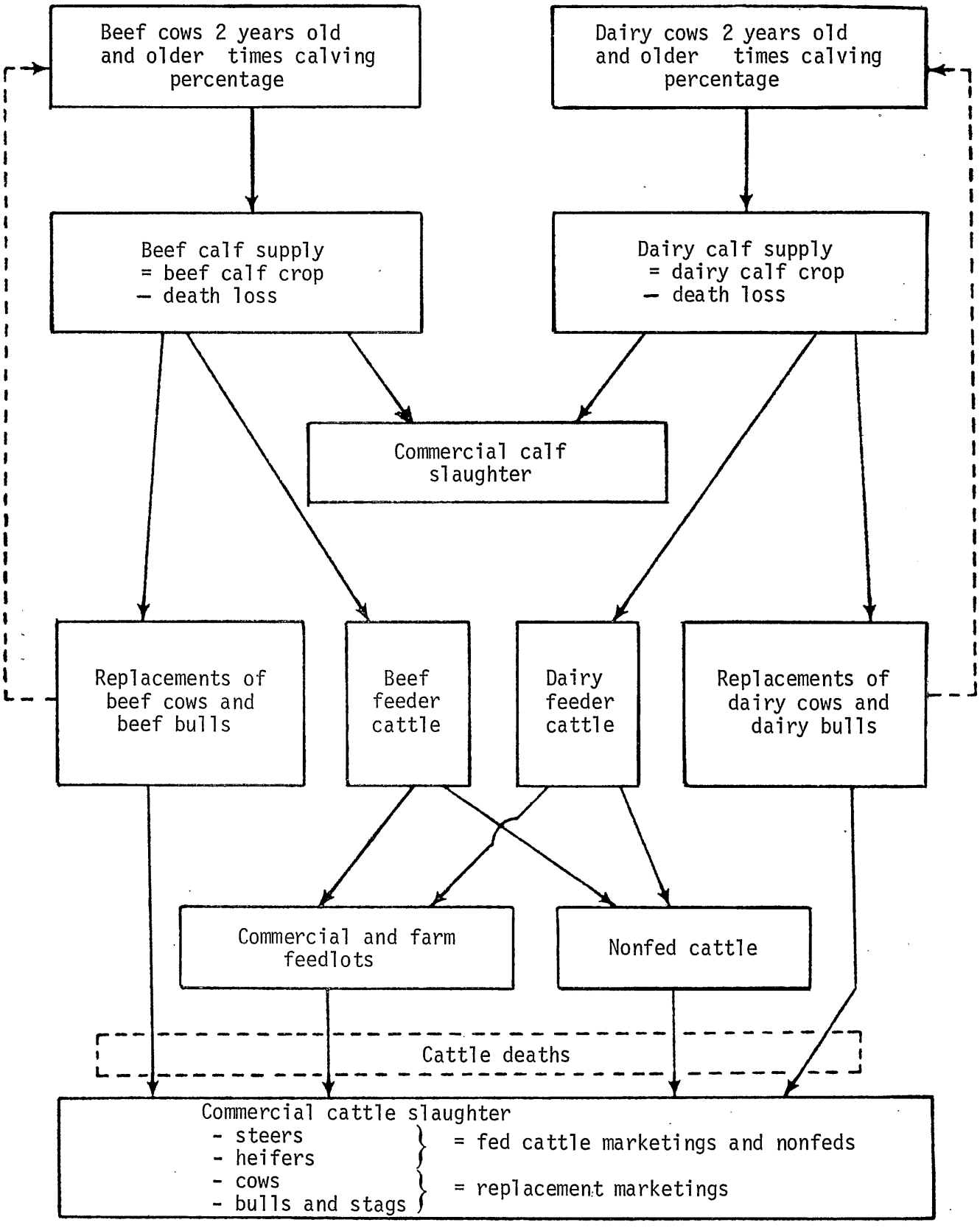
Such analysis requires some necessary assumptions which approximate but limit real events. These include:

1. Product homogeneity. (There is no real difference between a 500 lb. Montana beef calf and a 500 lb. Texas beef calf, for example. Breed and sex differences are ignored, except for beef-dairy distinctions.)
2. Pure competition. (There are no monopolistic operators, no one person can control prices paid or received, and there are no quarantines or other artificial restraints limiting interstate movement.)

[16] Forty U. S. regions, five regions representing exports from Mexico and Canada, and one dummy variable to equate total supply with total demand.

[17] Hitchcock, F. L. 1941. The Distribution of a Product from Several Sources to Numerous Localities. Journal of Mathematics and Physics, 2:224-230.

[18] Walker, F. E. March 22-23, 1964. Transportation and Spatial Equilibrium Models for Interregional Analysis. Paper presented at Southern Farm Management Research Committee Workshop, New Orleans.



APPENDIX FIG. I.—General alternative use flow chart for calves produced in the United States, from birth to slaughter.

3. Transfer costs are independent of volume shipped. (Transfer costs are based on semi-trailer truck rates. Nobody gets a quantity discount.)
4. All shipments are represented by one shipping point for each region. (Everything received in Ohio from other regions comes to Columbus or, alternatively, shipments from other regions into Ohio are based on their transfer cost to Columbus. Similar points represent other regions.)

Regional Boundaries

Regional boundaries and shipping points used in this analysis are summarized in Appendix Table I. Each U. S. region is formed by the boundaries of a single state with the exception of regions 2-42, 10-50, 17-57, and 38-78. Mexico is represented by two basing points and Canada by three.

The double numbers identifying regions accommodate separate analyses of optimum shipments for beef calves and dairy calves to feedlot and slaughter destinations. The general matrix form of this analytical approach appears in Appendix Figure II.

Estimating Regional Supplies

(See Appendix D for Foreign Supply)

Appendix Figure I provides an overview of supply determination requirements. The following data were basic sources in the derivation of calf supplies:[19] 1) cows and heifers 2 years old and older kept for milk, 2) heifers 1 to 2 years old kept for milk, 3) beef cows 2 years old and older, 4) bulls 1 year old and older, 5) total calves born, 6) total calf deaths, and 7) total cattle deaths. Total calves born, bulls 1 years old and older, and calf deaths are not reported separately for dairy and beef. Hence, for each state, these categories were divided between dairy and beef according to the percentage of cows 2 years old and older kept for milk and beef. The implied assumption is that calving percentages, bulls per cow, and death loss percentages are the same for both beef and dairy in a given state (see Appendix B).

From initial supplies of total dairy calves born and total beef calves born, adjustments were made for bull replacements, calf death losses, and cow replacements. Bull replacement rates were assumed to be 20 percent annually for both beef and dairy. The dairy cow replacement rate was assumed to be the number of heifers 1 to 2 years old kept for milk in each state. Since beef heifers 1 to 2 years old would include feeder heifers as well as replacement heifers, an independent procedure was used to delineate the beef cow replacement rate. The 1968 beef cow replacement rate was calculated as 13.72 percent (Appendix B).[20] Hence, state-by-state net calf supplies available either for feeding or slaughter were determined using the following general equations:

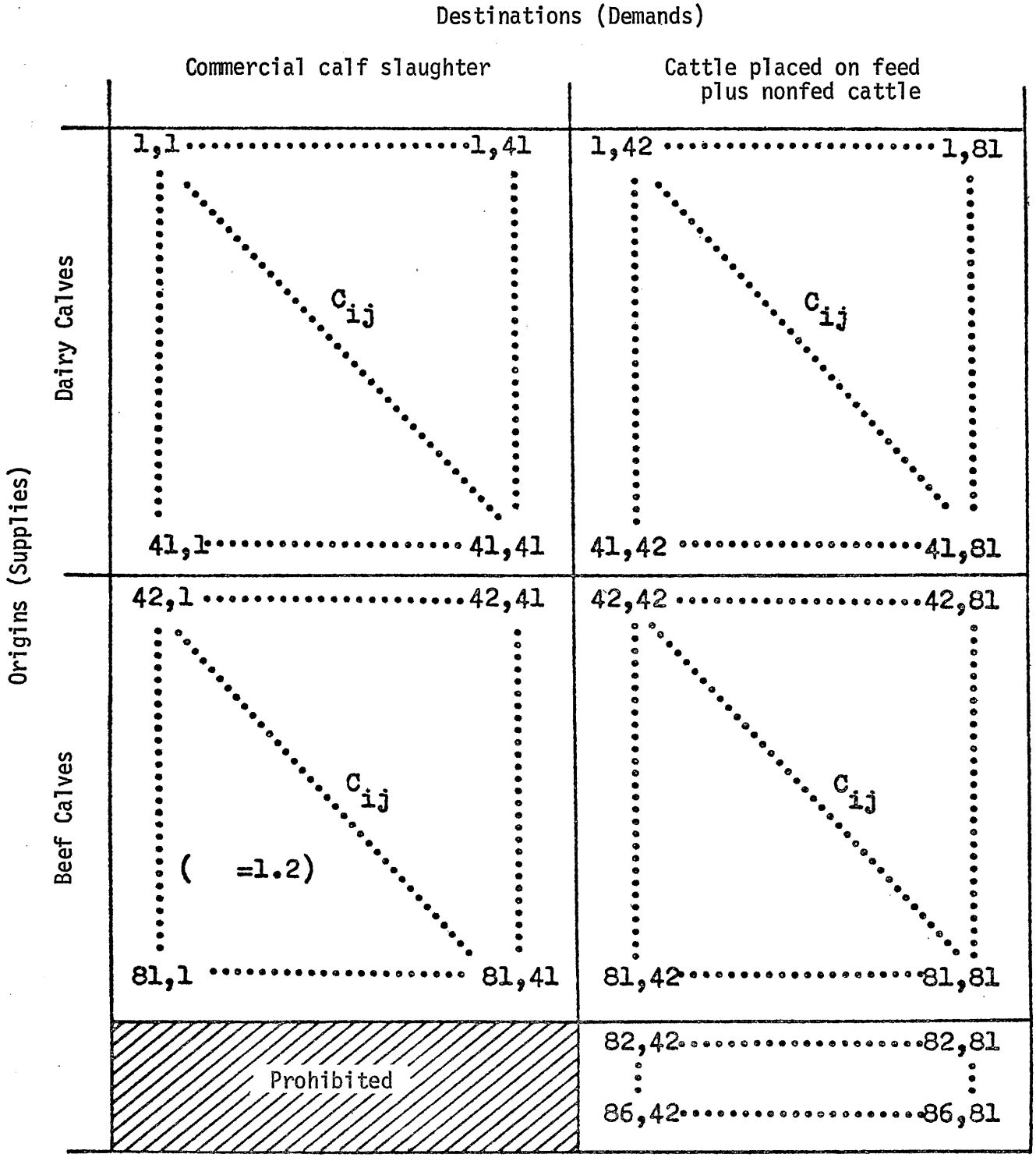
[19]These are reported in Livestock and Meat Statistics, Supplement to Statistical Bulletin 333, Livestock and Poultry Inventory, and Calf Crop, all reports of the Economic Research Service, USDA.

[20]An earlier study found typical replacement rates at 12 to 14 percent. See Armstrong, D. L. and E. T. Shaudys. May 1961. Profitability of Practices Affecting the Calf Crop of Beef Herds. Res. Circ. 103, Ohio Agricultural Experiment Station (now OARDC).

APPENDIX TABLE I.—Regional Demarcation and Shipping Points.

Region			
Dairy	Beef	Regional Identity	Shipping Point
1*	1	dummy variable	
2	42	Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut	Concord
3	43	New York	Syracuse
4	44	New Jersey	Trenton
5	45	Pennsylvania	Harrisburg
6	46	Ohio	Columbus
7	47	Indiana	Indianapolis
8	48	Illinois	Springfield
9	49	Michigan	Lansing
10	50	Wisconsin, Minnesota	St. Paul
11	51	Iowa	Des Moines
12	52	Missouri	Jefferson City
13	53	North Dakota	Bismarck
14	54	South Dakota	Pierre
15	55	Nebraska	Grand Island
16	56	Kansas	Wichita
17	57	Delaware, Maryland	Baltimore
18	58	Virginia	Roanoke
19	59	West Virginia	Charleston
20	60	North Carolina	Raleigh
21	61	South Carolina	Columbia
22	62	Georgia	Atlanta
23	63	Florida	Tampa
24	64	Kentucky	Lexington
25	65	Tennessee	Nashville
26	66	Alabama	Birmingham
27	67	Mississippi	Jackson
28	68	Arkansas	Little Rock
29	69	Louisiana	Alexandria
30	70	Oklahoma	Oklahoma City
31	71	Texas	Abilene
32	72	Montana	Billings
33	73	Idaho	Boise
34	74	Wyoming	Cheyenne
35	75	Colorado	Denver
36	76	New Mexico	Roswell
37	77	Arizona	Phoenix
38	78	Utah, Nevada	Ogden
39	79	Washington	Spokane
40	80	Oregon	Burn
41	81	California	Bakersfield
	82	Canada (east)	Montreal
	83	Canada (central)	Port Huron
	84	Canada (west)	Calgary
	85	Mexico (west)	Hermosillo
	86	Mexico (east)	Chihuahua

*Cell was maintained but not used in the model described.



APPENDIX FIG. II.—General matrix form for the transportation analysis.

1. Net dairy calves available for feeding or slaughter = total dairy calves born — dairy calf death losses — dairy bull replacements — dairy cow replacements.
2. Net beef calves available for feeding or slaughter = total beef calves born — beef calf death losses — beef bull replacements — beef cow replacements ± one-half of the change in the beef cow inventory.[21]

Estimating Transfer Costs

Transportation rates were determined from interviews with trucking firms and from rate schedules provided in research publications.[22] Transportation cost per head is primarily a function of distance traveled and the weight of cattle being hauled. Typical interstate rates charged for the shipment of feeder cattle into Ohio ranged from 60¢ to 80¢ per loaded mile. These rates were generally associated with 32,500 lb. load capacity straight semi-trailers and 42,500 lb. load capacity drop-center semi-trailers. For example, relationships for truck transportation rates and load capacities were as follows:

$0.60000 per loaded mile = $0.001846 per cwt. per mile for 32,500 lb. load.

$0.78455 per loaded mile = $0.001846 per cwt. per mile for 42,500 lb. load.

Transportation costs were charted for varying distances using freight rates and transportation cost functions from various sources. The chart indicated that the rates shown above were representative for shipments greater than 200 miles. All interstate shipments less than 200 miles and all intrastate shipments were assumed to be 20 percent higher ($0.002215 per cwt. per mile).

Moreover, transportation rates for beef calves moving to slaughter were set 20 percent higher than for dairy calves moving to slaughter. This differential was established to permit beef calves to move to slaughter, although they are commonly favored over dairy calves for feeding. The differential was established in recognition of the fact that dairy calves usually grade lower as feeders than beef calves, and after an examination of annual average feeder calf prices disclosed differentials between grades approximating 20 percent.

The desirability of this procedure was disclosed by initial attempts to formulate optimum shipment patterns without this restriction. Since the annual dairy calf crop exceeds annual veal slaughter, dairy calves were used to satisfy slaughter requirements in early models which permitted only dairy calves exceeding slaughter needs to move into feedlots. This restraint generated unrealistic shipment patterns. For example, regions having surpluses of beef calves relative to feedlot demand, but with insufficient dairy calves to meet local slaughter requirements, were shown to be importing dairy calves for slaughter from distant regions while exporting local beef calves to distant feedlot locations. Under the adjusted procedure, beef calves were no longer excluded from slaughter use, being permitted to compete with dairy calves for slaughter, although under a penalty which reflected their preferred use in feedlots.

Mileages between points for interstate shipments were determined from the Rand McNally Road Atlas of the United States. Distances for intrastate shipments were estimated by the authors based upon the characteristics of the cattle industry in each state. Examples would be distances from southeast Ohio to northwest Ohio and from the Gulf area of Texas to the Panhandle.

Program Analysis

With transfer costs estimated between each pair of regions and the supply and demand for cattle in each region determined, optimal shipment patterns were obtained by using the transportation model computer program developed by Dennis.[23] The program produced optimal shipment patterns between regions, the transportation cost for each shipment, the per unit cost for each shipment, the total transportation cost for all shipments, and the dual of the transportation problem. Shipments and freight costs are summarized in Appendix Table II.

[21]Since the January 1 inventory of beef cows and heifers 2 years old and older either increases or decreases annually, an adjustment was made to account for this factor. Thus, it was assumed that one-half of the increase in cow numbers would be accounted for by saving additional heifer calves and the other half would be accounted for by reducing culling such as holding cows for an extra calf or two. Correspondingly, a decrease would be accounted for by increasing the cow culling rate to the extent that it would account for one-half of the reduced inventory and reducing the number of heifers held for replacements to account for the other half of reduced inventory.

[22]Capener, William N., William P. Stevens, James S. St. Clair, and Harold Abel. Jan. 1969. Transportation of Cattle in the West. Res. Journal 25, Agricultural Experiment Station, University of Wyoming; and Futrell, Gene A., Francis E. Walker, and Thomas T. Stout. Nov. 1965. Econometric Generalizations of the Ohio Beef and Pork Industries in Interregional Competition. Res. Bull. 974, Ohio Agricultural Research and Development Center. Another list entitled Truckload Rates on Livestock Interstate Movement was received from Vernon M. Sheppard, Jr., Extension Specialist, Livestock Marketing, Virginia, in correspondence dated August 9, 1968.

[23]Dennis, J. B. April 1958. A High-Speed Computer Technique for the Transportation Problem. Journal of the Association for Computer Machinery, V(2).

APPENDIX TABLE II.—Allocation of Calves Sorted by Supply Regions, Number Shipped, Cost per Hundredweight, and Total Cost.

Supply Region†	Demand Region	Number Shipped	Cost per Hundred	Transportation Cost*	
				Slaughter	Feeding
				(Dollars)	
2	2	249,000	0.28	160,356	
	3	31,000	0.42	29,946	
	42	7,000	0.28		9,800
3	3	612,000	0.20	281,520	
4	4	51,000	0.11	12,903	
5	3	3,000	0.38	2,622	
	4	271,000	0.29	180,757	
	5	158,000	0.18	65,412	
6	3	1,000	0.83	1,909	
	6	84,000	0.25	48,300	
	46	17,000	0.25		21,250
	49	180,000	0.47		423,000
7	7	51,000	0.17	19,941	
	8	52,000	0.38	45,448	
	47	60,000	0.17		51,000
8	51	226,000	0.54		610,200
9	9	179,000	0.25	102,925	
	49	89,000	0.25		111,250
10	10	695,000	0.30	479,550	
	50	1,168,000	0.30		1,752,000
11	11	47,000	0.27	29,187	
	51	343,000	0.27		463,050
12	11	265,000	0.50	304,750	
13	53	50,000	0.31		77,500
	54	73,000	0.38		138,700
14	15	8,000	0.56	10,304	
	55	155,000	0.56		434,000
15	55	158,000	0.20		158,000
16	51	162,000	0.74		599,400
17	5	121,000	0.18	50,094	
18	5	147,000	0.51	172,431	
19	18	54,000	0.38	47,196	
20	4	78,000	0.80	143,520	
	17	30,000	0.56	38,640	
21	18	14,000	0.59	18,998	
	20	8,000	0.38	6,992	
	21	27,000	0.18	11,178	
22	22	39,000	0.27	24,219	
	26	42,000	0.28	27,048	
23	21	60,000	0.88	121,440	
	23	46,000	0.36	38,088	
24	24	8,000	0.25	4,600	
	47	256,000	0.38	486,400	
25	8	150,000	0.66	227,700	
	48	78,000	0.66		257,400
26	25	87,000	0.38	76,038	
27	27	109,000	0.30	75,210	
	28	19,000	0.47	20,539	
28	12	51,000	0.65	76,245	
	51	16,000	1.06		84,800
29	29	113,000	0.19	49,381	
30	16	4,000	0.36	3,312	
	30	23,000	0.25	13,225	
	56	77,000	0.36		138,600
31	31	242,000	0.63	350,658	

*Assume slaughter calves average weight equals 230 lb. and feeder cattle average weight equals 500 lb.

†Supply regions 2 through 41 are dairy calves, regions 42 through 81 are beef calves, and 82 through 86 represent foreign origins.

Source: Calculated from computer output.

APPENDIX TABLE II (Cont.)—Allocation of Calves Sorted by Supply Regions, Number Shipped, Cost per Hundredweight, and Total Cost.

Supply Region†	Demand Region	Number Shipped	Cost per Hundred	Transportation Cost*	
				Slaughter	Feeding
				(Dollars)	
32	32	1,000	0.61	1,403	
	38	7,000	0.90	14,490	
	78	26,000	0.90		117,000
33	33	1,000	0.18	414	
	40	17,000	0.35	13,685	
	73	78,000	0.18		70,200
34	75	14,000	0.24		16,800
35	35	2,000	0.31	1,426	
	75	63,000	0.31		97,650
36	36	1,000	0.38	874	
	37	4,000	0.93	8,556	
	76	17,000	0.38		32,300
37	41	30,000	0.90	62,100	
38	41	53,000	1.22	148,718	
39	39	17,000	0.20	7,820	
	79	90,000	0.20		90,000
	80	16,000	0.66		52,800
40	41	69,000	1.44	228,528	
41	41	103,000	0.48	113,712	
	81	368,000	0.48		883,200
42	42	15,000	0.28		21,000
43	3	32,000	0.24	17,664	
44	4	4,000	0.13	1,196	
45	5	62,000	0.22	31,372	
46	46	217,000	0.25		271,250
47	48	294,000	0.38		558,600
48	51	561,000	0.54		1,514,700
49	49	74,000	0.25		92,500
50	50	94,000	0.30		141,000
	51	379,000	0.47		890,650
51	51	966,000	0.27		1,304,100
52	51	1,284,000	0.50		3,210,000
53	54	691,000	0.38		1,312,900
54	55	1,223,000	0.56		3,424,400
55	55	1,393,000	0.20		1,393,000
56	51	148,000	0.74		547,600
	55	809,000	0.56		2,265,200
	56	271,000	0.22		298,100
57	5	38,000	0.22	19,228	
58	18	120,000	0.24	66,240	
	45	156,000	0.51		397,800
	58	22,000	0.20		22,000
59	19	5,000	0.16	1,840	
	46	15,000	0.38		28,500
	58	40,000	0.38		76,000
	59	62,000	0.13		40,300
60	44	17,000	0.80		68,000
	57	64,000	0.56		179,200
	58	111,000	0.38		210,900
61	21	55,000	0.22	27,830	
	60	91,000	0.38		172,900
62	22	1,000	0.32	736	
	62	187,000	0.27		252,450
	64	278,000	0.63		875,700
	66	21,000	0.28		29,400

*Assume slaughter calves average weight equals 230 lb. and feeder cattle average weight equals 500 lb.

†Supply regions 2 through 41 are dairy calves, regions 42 through 81 are beef calves, and 82 through 86 represent foreign origins.

Source: Calculated from computer output.

APPENDIX TABLE II (Cont.)—Allocation of Calves Sorted by Supply Regions, Number Shipped, Cost per Hundredweight, and Total Cost.

Supply Region†	Demand Region	Number Shipped	Cost per Hundred	Transportation Cost*	
				Slaughter	Feeding
				(Dollars)	
63	23	177,000	0.43	175,053	
	61	53,000	0.88		233,200
	63	245,000	0.36		441,000
64	46	321,000	0.38		609,900
	47	336,000	0.38		638,400
65	48	569,000	0.66		1,877,700
66	25	54,000	0.46	57,132	
	48	235,000	1.00		1,175,000
	65	167,000	0.38		317,300
	66	90,000	0.27		121,500
67	27	4,000	0.36	3,312	
	48	237,000	1.10		1,303,500
	52	360,000	1.03		1,854,000
	67	57,000	0.30		85,500
	68	105,000	0.47		246,750
68	51	470,000	1.06		2,491,000
	52	67,000	0.65		217,750
69	29	120,000	0.23	63,480	
	52	400,000	0.98		1,960,000
	69	36,000	0.19		34,200
70	56	1,415,000	0.36		2,547,000
71	31	104,000	0.76	181,792	
	51	237,000	1.30		1,540,500
	70	543,000	0.59		1,601,850
	71	2,432,000	0.63		7,660,800
	77	13,000	1.55		100,750
	81	234,000	2.29		2,679,300
72	53	104,000	0.80		416,000
	72	271,000	0.61		826,550
	73	114,000	1.00		570,000
	74	125,000	0.88		550,000
	75	320,000	1.07		1,712,000
	78	179,000	0.90		805,500
73	73	326,000	0.18		293,400
	80	65,000	0.35		113,750
74	75	501,000	0.24		601,200
75	75	734,000	0.31		1,137,700
76	76	379,000	0.38		720,100
	77	87,000	0.93		404,550
77	81	224,000	0.90		1,008,000
78	81	413,000	1.22		2,519,300
79	79	269,000	0.20		269,000
80	80	146,000	0.32		233,600
	81	345,000	1.44		2,484,000
81	81	689,000	0.48		1,653,600
82	42	12,000	0.39		23,400
	43	33,000	0.47		77,550
83	49	33,000	0.31		51,150
84	79	29,000	0.85		123,250
85	77	174,000	0.65		565,500
86	77	528,000	1.17		3,088,800
Subtotal dairy calves (4,572,000 slaughter and 3,698,000 feeding)				4,460,708	6,689,900
Subtotal beef calves (738,000 slaughter and 24,294,000 feeding)				646,875	69,582,950
TOTAL				5,107,583	76,272,850

*Assume slaughter calves average weight equals 230 lb. and feeder cattle average weight equals 500 lb.

†Supply regions 2 through 41 are dairy calves, regions 42 through 81 are beef calves, and 82 through 86 represent foreign origins.

Source: Calculated from computer output.

APPENDIX B

Allocation of Commercial Slaughter, Death Losses, Replacement Rates

Commercial Slaughter

Federal inspected (FI) slaughter, which accounts for approximately 85 percent of commercial slaughter, is reported by slaughter categories (see Appendix Table III). Commercial slaughter is not similarly reported. The percentage distribution of FI slaughter categories was used to generate a percentage distribution for commercial slaughter. There is no evidence from previous research that this is not a satisfactory procedure. However, the procedure is subject to error to the extent that non-FI slaughter plants may tend to focus their activity on different market classes of cattle. This may be particularly true in the case of nonfed cattle, about which little is known. As nonfed cattle continue to decline in importance, problems in identification and classification of commercial slaughter will decrease.

Death Losses

Total 1968 cattle death losses were reported at 1,521,000 head.[24] This total was allocated to dairy and beef in the following manner:

348,773	from fed cattle marketings (1.5% of 23,251,000)[25]
850,000	beef cows (2.4% of 35,314,000 beef cow inventory)
322,227	dairy cows (2.2% of 14,626,000 dairy cow inventory)
1,521,000	total death losses

[24]Livestock and Meat Statistics Supplement for 1968 to Bulletin No. 333, p. 30. Statistical Reporting Service, USDA.
[25]Adjusted to include 39 states.

APPENDIX TABLE III.—Number and Percentage Distribution of Federal Inspected and Commercial Slaughter, 1968.

Slaughter Class	Federal Inspected Slaughter*	Percentage FI Slaughter	Commercial Slaughter Equivalent
Steers	15,361,000	51.9	18,178,702
Heifers	7,986,000	27.0	9,457,128
Cows	5,785,000	19.5	6,830,148
Bulls and Stags	459,000	1.6	560,422
Total	29,591,000	100.0	35,026,400*

*As reported in Livestock and Meat Statistics, Bull. 333, SRS, USDA.

Replacement Rates

From commercial cow slaughter of 6,830,148 head (Appendix Table III) and beef and dairy death rates (left), the beef cow replacement rate was derived as follows:

Commercial cow slaughter		6,830,148
Dairy cow replacement	3,575,000	
less dairy cow deaths	322,227	
Net dairy cows slaughtered		3,252,773
Net beef cows slaughtered		3,577,375
plus beef cow deaths	850,000	
plus ½ change in beef cow inventory	418,500	
Total adjustments		1,268,500
Total beef cows replaced		4,845,875

$$\text{Beef Cow Replacement Rate} = \frac{\text{Total Beef Cows Replaced}}{\text{January 1 Beef Cows 2 Years Old and Older}} = \frac{4,845,875}{35,314,000} = 13.72 \text{ percent}$$

APPENDIX C

Allocation of Nonfed Cattle

A helpful insight for allocation of nonfed cattle is found in the 1964 Census of Agriculture which reports cattle sales in two categories: 1) all cattle sold, and 2) cattle fed grain and concentrate and sold for slaughter. The following procedure was used to estimate nonfed cattle in individual states:

All cattle sold, excluding calves (1964 Census) less cattle fattened and sold for slaughter (1964 Census) less replacement cows and bulls sold for slaughter (Appendix B) = residual of cattle marketings for other purposes.

This residual represents, in effect, the maximum number of nonfed cattle which can be allocated to any individual state. From this residual, a final allocation was determined. The collective residuals for individual states determined above yields a total (8,914,506 head) exceeding the national nonfed total (3,581,672 head). An allocation based on the national total is therefore required. However, allocation on the basis of a percentage distribution of residual marketings is unsatisfactory. For example, it might be reasonable to suppose that small Eastern states with dense population, little feeding, and large cattle deficits might yield a higher percentage of nonfed cattle in total slaughter marketings. Hence, states were divided into two categories: those in which total residual marketings were treated as nonfed marketings, and those in which the remaining possible total of nonfed cattle was allocated to individual states on the basis of the regional percentage distribution of residual marketings (see Appendix Table IV).

APPENDIX TABLE IV.—Allocation of 1968 Nonfed Cattle Marketings Based on Residual Marketings Calculated from 1964 Census.

State	Residual of Cattle Marketings for Other Purposes	Percent	Allocation of Nonfeds	Percent of Nonfeds
(States with all residual marketings treated as nonfeds)				
Maine	3,944		3,944	.11
New Hampshire	2,270		2,270	.06
Vermont	9,620		9,620	.27
Massachusetts	11,211		11,211	.31
Rhode Island	2,160		2,160	.06
Connecticut	5,234		5,234	.15
New York	18,165		18,165	.51
New Jersey	17,132		17,132	.48
Pennsylvania	18,297		18,297	.51
Ohio	134,080		134,080	3.74
Indiana	156,609		156,609	4.37
Michigan	120,131		120,131	3.35
Wisconsin	87,988		87,988	2.46
Delaware	3,137		3,137	.09
Maryland	23,732		23,732	.66
Virginia	134,101		134,101	3.74
West Virginia	62,127		62,127	1.73
North Carolina	38,943		38,943	1.09
South Carolina	27,504		27,504	.77
Georgia	68,055		68,055	1.90
Florida	125,082		125,082	3.49
Kentucky	187,660		187,660	5.25
Tennessee	117,115		117,115	3.27
Alabama	47,341		47,341	1.32
Mississippi	14,989		14,989	.42
Arkansas	79,014		79,014	2.21
Louisiana	19,146		19,146	.53
Subtotal	1,534,787		1,534,787	42.85
(States with a percentage of residual allocated as nonfeds)				
Illinois	252,641	3.42	70,010	1.95
Minnesota	308,069	4.17	85,364	2.38
Iowa	552,873	7.49	153,327	4.28
Missouri	343,938	4.66	95,394	2.66
North Dakota	157,436	2.13	43,603	1.22
South Dakota	408,887	5.54	113,409	3.17
Nebraska	725,395	9.83	201,229	5.62
Kansas	992,826	13.45	275,334	7.69
Oklahoma	359,777	4.88	99,898	2.79
Texas	711,185	9.64	197,339	5.51
Montana	352,516	4.78	97,851	2.73
Idaho	206,734	2.80	57,319	1.60
Wyoming	238,454	3.23	66,121	1.85
Colorado	425,063	5.76	117,912	3.29
New Mexico	200,765	2.72	55,681	1.55
Arizona	149,948	2.03	41,556	1.16
Utah	57,560	.78	15,967	.45
Nevada	93,033	1.26	25,793	.72
Washington	175,823	2.38	48,721	1.36
Oregon	166,760	2.26	46,264	1.29
California	500,036	6.78	138,793	3.88
Subtotal	7,379,719		2,046,885	57.15
TOTAL	8,914,506		3,581,672	100.00

APPENDIX D

Foreign Inshipments

The number, type, and location of cattle imported from Mexico and Canada were required for the analysis. In 1968, the U.S. received 702,000 head of cattle from Mexico which, based on the light weights reported, were intended principally for feeding.[26] Two points of origin were used for Mexican inshipments: Hermosillo representing western origins and Chihuahua representing eastern Mexico. Since the greatest concentration of Mexican cattle is in the eastern Gulf area, two-thirds of all Mexican inshipments (528,000) were allocated to Chihuahua.

The United States imported 322,000 cattle from Canada in 1968.[26] Careful treatment of these Canadian cattle is critical due to the length of the international boundary and to the fact that small Canadian calves move both to feedlots and to slaughter. With the assistance of the Foreign Agricultural Service, USDA, an examination was made of the unpublished record of individual Canadian inshipment transactions recorded in 1969. The examination revealed that 13 ports of entry accounted for 95.4 percent of total inshipments and 98.0 percent of all inshipments for slaughter during 4 sample months of that year.[27] Three dominant ports of entry were Montreal (eastern Canada), Port Huron (central Canada), and Calgary (western Canada); these were selected as basing points for the analysis. On the basis of the 1969 sample data, 1968 inshipments were identified for feedlot and slaughter use and proportionately allocated to each of the three basing points (Appendix Table V).

[26]U. S. Foreign Agricultural Trade by Countries, Calendar Year 1968. Foreign Agricultural Trade of the United States, monthly supplement, February 1970, Economic Research Service, USDA.

[27]Compiled from unpublished records maintained by Foreign Agricultural Service, USDA, Washington, D. C. Sample months were January, April, July, and October.

Appendix Table V.—Inshipments of Cattle from Canada. Allocation of Total Inshipments to Regional Origins, by Intended Use, 1968.

Region and Sample Ports of Entry	FAS Sample Data			Allocation of 1968 Inshipments		
	Number for Slaughter	Total Number	Percent Slaughter	Number for Slaughter	Number for Feeding	Total Inshipments
Montreal (East)	46,280	57,851	80.00	178,491	44,623	223,114
Champlain, N.Y.	20,220	22,130				
Ogdensburg, N.Y.	18,500	18,576				
Alexandria Bay, N.Y.	1,865	6,330				
Buffalo, N.Y.	1,495	5,325				
Richford, Vt.	1,900	1,910				
Highgate Springs, Vt.	2,390	2,640				
Horton, Maine	310	940				
Port Huron (Central)	2,165	10,615	20.40	8,349	32,577	40,926
Port Huron, Mich.	370	3,795				
Pembena, N. Dak.	1,795	6,820				
Calgary (West)	7,415	15,025	49.35	28,603	29,357	57,960
Sweet Grass, Mont.	2,030	3,320				
Port Idaho, Idaho	4,160	5,375				
Blaine, Wash.	1,085	2,090				
Orville, Wash.	140	4,240				
Total	55,860	83,491	66.91	215,443	106,557	322,000

Source: Sample data, Foreign Agricultural Service, and calculations.

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Center Headquarters, Wooster, Wayne County: 1953 acres

Eastern Ohio Resource Development Center, Caldwell, Noble County: 2053 acres

Green Springs Crops Research Unit, Green Springs, Sandusky County: 26 acres

Jackson Branch, Jackson, Jackson County: 344 acres

Mahoning County Farm, Canfield: 275 acres

Muck Crops Branch, Willard, Huron County: 15 acres

North Central Branch, Vickery, Erie County: 335 acres

Northwestern Branch, Hoytville, Wood County: 247 acres

Pomerene Forest, Laboratory, Keene Township, Coshocton County: 227 acres

Southeastern Branch, Carpenter, Meigs County: 330 acres

Southern Branch, Ripley, Brown County: 275 acres

Western Branch, South Charleston, Clark County: 428 acres